ORIGIN OF THE PRONEPHRIC DUCT IN SELACHIANS.

EMILY RAY GREGORY.

A RENEWED study of the origin of the pronephric duct in Selachians was suggested to me by Dr. W. M. Wheeler of the University of Chicago, in whose laboratory the work has been carried on, and to whom I am indebted for the material used and for helpful directions.

There have been different opinions on this subject, which are well represented by the papers of Joh. Rückert,[1] J. W. van Wyhe,[2] and Carl Rabl,[3] to which reference will be made later. The paper by Laguesse,[4] who also used *Acanthias*, was inaccessible. The material used was *Acanthias* embryos, of which there were quite a number, showing different stages of development. Several methods of killing and hardening were employed, but all gave essentially the same results. Cross sections were examined with great care, so that no misinterpretation might occur through slanting sections; and where a question of fusion was involved, a Zeiss $\frac{1}{12}$ immersion lens was employed.

In an embryo of 25 somites the Anlage of the pronephros is seen to consist of segmental outgrowths of the somatic layer of the somites, beginning at the seventh and extending over six segments. There is a slight difference in the development on the two sides of the embryo in respect to the position of the anterior end. These outgrowths are connected with the ectoderm at their outer edge, and in places this layer seems to

[1] Ueber die Entstehung der Excretionsorgane bei Selachiern, Joh. Rückert, *Archiv. für Anat. und Phys.*, 1888.

[2] Ueber die Mesodermsegmente des Rumpfes und die Entwickelung des Exkretionssystems bei Selachiern, J. W. van Wyhe, *Arch. f. m. Anat.*, Bd. 33, 1889.

[3] Ueber die Entwicklung der Urogenitalsystems der Selachier, Carl Rabl, *Morph. Jahrbuch*, Heft 4, 1896.

[4] Sur le développement du Mesenchyme et du pronéphros chez les Sélaciens (Acanthias), *Comptes rendus hebdomadaires des séances et mémoires de la Société de Biologie*, tome iii, série ix, 1891.

have proliferated at the point of union, and to have become more than one cell thick. When this connection with the ectoderm is artificially severed, the appearance of the Anlage and the overlying ectoderm shows that the connection must have been a true fusion. In some cases the Anlage seems to carry away with it a few cells of ectodermal origin. Camera drawings showing these conditions from the two sides of an

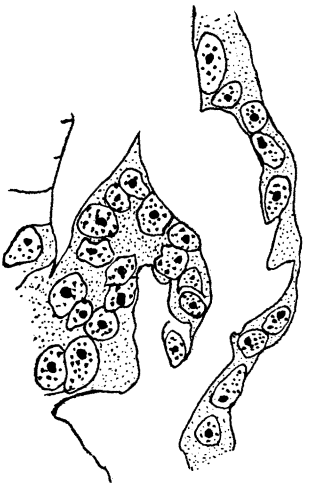


FIG. 1.

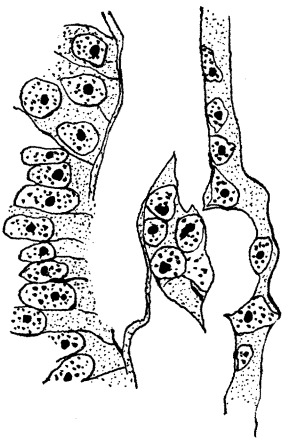


FIG. 2.

embryo are seen in Figs. 1 and 2. This fusion is, however, of very short duration, and there is no sign of it in later stages.

The part of the duct receiving the pronephric collecting tubules is developed with the pronephros from this same Anlage, but the origin of the duct proper, *viz.*, that portion which lies beyond the last pronephric tubule, is more difficult to establish. The preparations made showed in all stages a very constant condition of fusion between the tip of the distally growing duct and the ectoderm. In some cases this fusion extended for a considerable distance, in others over only a few sections, perhaps not more than one or two. There were only one or two exceptions, which could be readily explained by accidental separation or from the short duration of the union. On the other hand, there were cases where the duct existed perfectly free in the space between the somites and the ecto-

derm for such a distance that the sudden turn and fusion with the ectoderm was very marked.

Fig. 3 (*a, b, c, d, e*) shows five successive sections at the end of the left pronephric duct of an embryo 5 mm. long (about 33

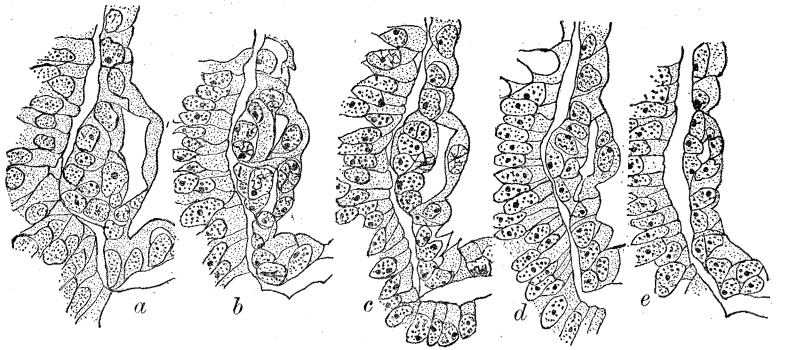


FIG. 3.

somites). Fig. 4 (*a, b*) shows two sections near the end of the right duct of the same embryo. Fig. 5 (*a, b, c, d, e, f*) shows the conditions at the end of the left duct of another embryo 5 mm. long (about 30 somites). Between *e* and *f* ten sections

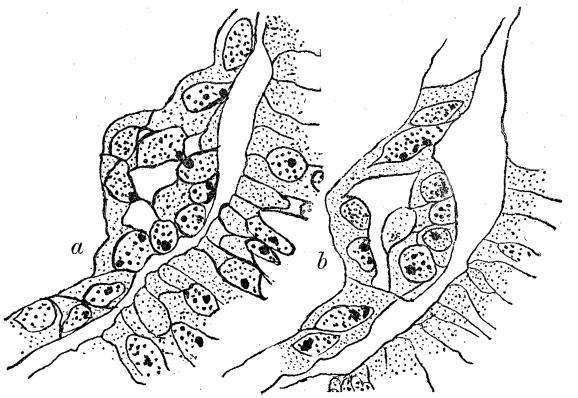


FIG. 4.

similar in character to *e* are omitted. In *f* the two cells which form the end of the duct are deeply stained and readily distinguished from the others. In this case the fusion is of unusually long duration. In addition to many series like the above,

one section was found (Fig. 6) in which it is evident from the deeper stain of the nuclei that karyokinesis has just taken place between the ectoderm and the duct. It is not possible that these are two adjacent cells dividing longitudinally, since the sections immediately preceding and following show no such condition.

While the duct is separating from the ectoderm in the older regions, the point of division is very often marked by projecting points of tissue on both duct and ectoderm. Sometimes

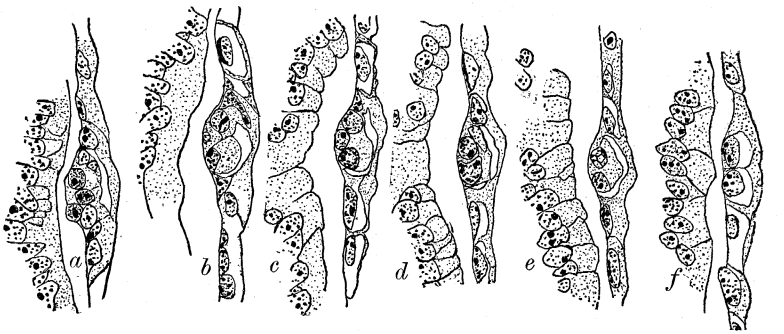


FIG. 5.

this may be noticeable only on the one or the other. Drawings of two such sections are represented (Fig. 7, *a*, *b*).

A very few division figures were found in the duct, but its increase in size while separated from all other tissues would of itself indicate that such growth must take place. Although the duct frequently lies for much of its length close against the somites, there is always a distinct line of separation. The nuclei in the outer mesodermal layer are also very constantly found at the inner end of the cells, as may be seen from the sections figured. In frontal sections the entirely different and independent arrangement of cells in the duct and in the somites is also very marked.

Fig. 8 is a reconstruction from frontal sections of an embryo 6½–7 mm. long, with about 38 somites (two gill slits open). This shows that the pronephros on the right side consists of six tubules, the first of which is developed from the 7th somite, with four aortic branches running between. At either end is

another small diverticulum of the aorta. The duct lies close against the mesoderm as far as the 26th somite, where it bends outwards and fuses with the ectoderm opposite the 27th somite. The fusion continues to the end of the duct opposite the 29th somite. The pronephros on the left side of the same embryo also begins at the 7th somite, but has only five tubules with three aortic diverticula. The end of the left duct may be seen in the figure. The aortic branches on the right side seem to correspond very closely with the descriptions already given by Paul Mayer, Rückert, van Wyhe, and Rabl. On the left there seem to be only wide pockets pushed out from the aorta. In embryos of from 7 to 10 mm. long these reach the wall of the pronephric tubule. Running from one to another (in one case over three successive segments) were found structures which may be interpreted as glomi. These have also been seen by van Wyhe, who says (p. 480): "Es ist klein, sehr vergänglich und besteht aus einem gefässführenden Strang, der von der dorsalen Lippe eines Ostiums in schräger Richtung zur ventralen zieht. Der Strang erstreckt sich in seiner Mitte ringsum vom Peritonealepithel bekleidet, frei durch die Leibeshöhle, und ist an beiden Enden befestigt." Similar rudimental glomi were found on the right side, although the presence of the "Darmgefässe" modifies their position. The objection made by Rabl to this interpretation does not seem to be tenable in the case of a rudimental organ, where one does not expect to find the structure perfect or complete.

FIG. 6.

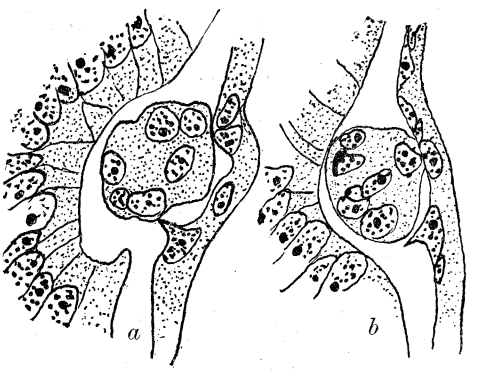
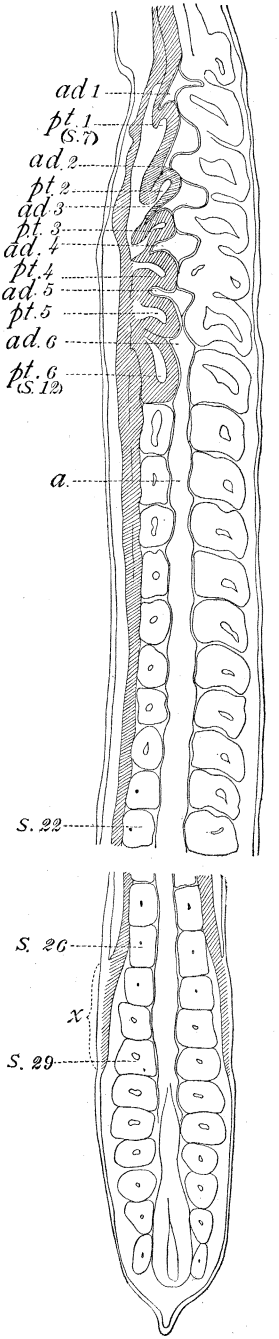


FIG. 7.

In a number of the embryos the primitive ova containing



granules resembling yolk, mentioned by Balfour and other observers, are very conspicuous. They occur in the somatopleure as well as in the splanchnopleure.

From the facts here given it seems reasonable to conclude that the earliest Anlage of the pronephros fuses temporarily with the ectoderm, and may possibly receive some few cells from it. The first part of the duct proper, lying just beyond the last pronephric tubule, seems necessarily to share to some slight degree in the mesodermal origin of the anterior region. This follows from the fact that there is no line of division between the two regions of the duct, and that Rabl and other observers have shown that karyokinesis occurs throughout the length of the duct. Most important of all, we must conclude that so far as the duct develops distally, the connection of its tip with the ectoderm is maintained. The mere fact of the actual fusion of the tip of the duct with the ectoderm throughout its growth would be sufficient evidence of a genetic relation for those who accept the principle of the teloblastic growth of organs. The position of the pronephros in *Acanthias* seems to be identical with that in *Pristiurus* as found by van Wyhe and Rabl. It will be seen that the results here

FIG. 8. — a = aorta, ad = aortic diverticulum, pt = pronephric tubule, S = somite, x = fusion of duct with ectoderm.

given correspond with those of Rückert (p. 215) in so far as the union of the Anlage of the pronephros with the ectoderm is concerned. Apparently Rabl describes the same thing in his "sichelförmige Masse" or "Strang" (637), but the appearance of the ectoderm in his drawings, though somewhat diagrammatic (XIII, 3, 4, 5, 11, 12), seems to support Rückert's interpretation of the immediate relations rather than his own. The phylogenetic conclusions might be the same. In regard to the genetic connection between the ectoderm and duct the results harmonize with those of Rückert and van Wyhe. It seems impossible, however, to draw so sharp a line as Rückert has drawn between the end of the pronephros and the beginning of the duct, and to say that the duct is derived only from the ectoderm. On the appearance of the paper by Rabl, my preparations were again examined carefully, but without finding any grounds for abandoning the view that there is a genetic connection between the duct and the ectoderm in Selachians.

UNIVERSITY OF CHICAGO,
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